Electrical Characterization of Resistive Switching Memories

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ABSTRACT

Metal oxide based resistive switching memories, also known as resistive-RAM (RRAM), have shown promising characteristics for next-generation nonvolatile memory and reconfigurable logic applications. These devices can be electrically switched between a low-resistance-state (LRS) and high-resistance-state (HRS) over many cycles. Fig. 1(a) illustrates the resistive switching terminologies and the operation parameters. A typical unipolar switching I-V curve is shown in Fig. 1(b) where key switching parameters are defined. Various metal oxides have demonstrated resistive switching properties. However, the measured switching parameters vary in a wide range, which calls for more consistent and uniform characterization methodologies. Although standard nonvolatile memory measurement methods are applicable to RRAMs, some unique features of RRAMs require carefully designed characterization approaches and not all the commonly used memory criteria can be simply extended to RRAMs. As an example, Fig. 1(c) shows a temperature-accelerated retention measurement of RRAMs [1]. A barrier-controlled retention model derived from the analogy to other nonvolatile memories (e.g., Flash memory) enables accurate retention measurement; however, the physical interpretation of the retention parameters is still debatable. Variability presents a major challenge for not only RRAM performance but also the characterization methodology. Phenomenological failure analysis has shown some abnormal failure modes during RRAM cycling, which needs to be addressed with rigorous testing algorithms [2]. Realistic RRAM evaluation and benchmark based on electrical characterization also needs to consider tradeoffs among key switching parameters.

This paper will discuss characterization methodologies for RRAMs in the following four categories: (1) standard measurement methods and RRAM parameters including switching voltage/current, speed, cycling endurance, retention, *etc*.; (2) characterization methods to explore the transport and switching mechanisms; (3) unique issues of RRAMs including switching polarity effects, switching control, reliability, variability, *etc*.; (4) tradeoffs among key switching parameters and failure modes important for RRAM evaluation and benchmark. Fig. 1(d) illustrates the four levels of RRAM characterization methodologies discussed in this paper.

Keywords: Resistive switching, RRAM, memory characterization, failure modes, variability

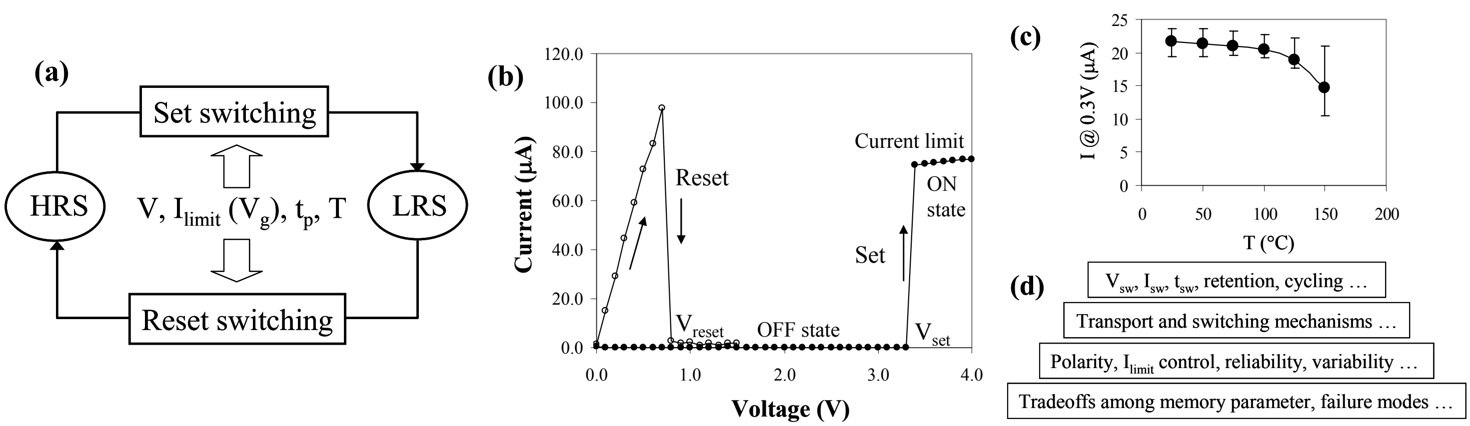

FIGURE 1. (a) Controllable operation parameters for resistive switching; (b) a typical unipolar resistive switching I-V curve; (c) temperature-accelerated retention measurement; (d) four levels of electrical characterization discussed in this paper.

REFERENCES

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